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NEW ENGLAND

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VOL. II. OCTOBER, 1883. No. 10.

ORIGINAL COMMUNICATIONS.

ROLE OF BACTERIA IN FERMENTATION AND PUTREFACTION.

BY C. S. BOYNTON, M. D., BRANDON, VT.

[Read before the American Dental Convention, at Saratoga, N. Y., August, 1883.]

We often refer with pride to the fact that we live in an age of progress, and point with admiration to the rapid strides which science has made in the last half-century.

But if we pause and consider how long many discoveries, of priceless value to humanity, have been hidden under the bushel of professional prejudice, or lies openly revealed before any steps are taken towards their practical application, humiliation takes the place of pride; and we find the same spirit that disputed the truths of Galileo and Hunter still alive.

For more than two thousand years the attraction of light bodies by amber was the sum of human knowledge regarding electricity, and for more than two thousand years fermentation was effected without any knowledge of its cause.

"Our remote ancestors had learned by experience that 'Wine maketh glad the heart of man.' Noah, we are informed, planted a vineyard, drank of the wine and experienced the consequences."

It is a matter of history that one discovery grows out of or follows another, and cannot appear without its proper antecedent.

Thus the microscope had to be invented and brought to a considerable degree of perfection before the phenomena of fermentation could be understood.

In the year 1680, Leeuwenhock found yeast to be a mass of floating globules, and for a period of one hundred and fifty years this was all that was known regarding it.

In 1837, Schwann clearly established the connection between putrefaction and organic life; but thirty years had to elapse before Lister extended to wounds the results of the researches of Schwann on dead flesh and animal infusions.

Prior to Lister, the possibility of some such extension had occurred to other minds.

Observing men had noticed the action of germs which produced putrefaction of meat, and had asked themselves the question, Might not these same germs act with fatal effect in the wards of a hospital?

The physicians of this period, guided entirely by empirical knowledge, were in this respect "wiser than they knew."

They had discovered the evils incident to dirt, and, by keeping dirt away from them, had saved many lives; but why dirt was fatal, few of them knew. Lister came forward with this scientific truth: Dirt was fatal, not as dirt, but because it contained living germs which Schwann was the first to prove are the cause of putrefaction, thus by one step changing the art of surgery into a science.

In 1864, in a paper read before the British Medical Association, Mr. Spencer Wells pointed out that the then recent experiments of Pasteur had "all a very important bearing upon the development of purulent infection and the whole class of diseases most fatal in hospitals and over-crowded places."

Two years prior to this, Dr. William Budd had drawn up a series of "Suggestions towards a Scheme for the Investigation of Epidemic and Epizootic Diseases." "What we most want to know," says Budd, "in regard to this whole group of diseases is, *where and how the specific poisons which cause them breed and multiply.*"

The word poisons here employed was a concession on Budd's part to his weaker brethren; for he, without a shade of doubt, considered the poison to be a real living seed.

From this time on, the investigation has progressed, carried on in the old Baconian lines of observation and experiment—spurred on by the investigations of Burdon, Sanderson, Koch, and others.

It has grown and multiplied till the germ theory has forced itself

upon the notice of every scientist, whether he would accept the doctrine or not. It has solved many a problem which hitherto has been looked upon as past finding out, or blindly accepted as a punishment sent by the Almighty for the sins of the people.

But the progress of these investigations has been greatly hindered by the popular fallacy in the minds of many of confounding scientific knowledge with practical uselessness.

The scientific thinker is met on all sides by the oft-repeated question, "Will it pay?" or, "What is the use?"

It is natural for man to wish to investigate whatever gives evidence of thought. The field of thought is the home of a thinking being, the home of man; and whatever manifests thought, without evil associations, is never to be regarded as useless. He may not have so far analyzed his intellectual forces as to know why he is impelled to this or that investigation. He is unable to give a satisfactory answer to those who demand the use. But he knows there is a use, as he knows that food strengthens the body, although he may be in happy ignorance of such an organ as the stomach, and have no notion of the peculiar office of carbon and nitrogen compounds. He cannot tell how food acts, but he goes on eating, for his appetite demands it; and, in satisfying its cravings, the good of the body is cared for.

So this intellectual appetite has led men to dig among ruins, to wipe the dust from the ancient inscription, to gather as a pearl every monument of human thought, to scan every form of matter as it exists in nature—the crystal and the flower—the animal, from the largest to the animalcule—those now living, and those sleeping in their beds of stone. This intellectual appetite has led men to labor, though unable to frame arguments in favor of what they knew to be right, and it has always led them in the right direction. With us, physical activity is considered by many the chief end of man. In the general apprehension, the study-lamp of the student shines on an idle dreamer—a drone in the great hive.

Says one of the profoundest philosophers that England ever produced, "It would not be difficult, by an unbroken chain of historic facts, to demonstrate that the most important discoveries in science and improvements in the mechanic arts had their origin, not in the cabinets of statesmen or in the practical insight of men of business, but in the visions of recluse genius."

But popular opinion is fast finding out that "the unobtrusive thinker is not a cipher at the left hand of society," and nowhere is this truth

more apparent than in the results that are being reached by the study of these organisms which we are now considering. The agriculturist, the silk-grower, the vine-dresser, the brewer, the surgeon, the physician, the dentist, the architect, have each in turn sought counsel of the scientist and his microscope, and in every instance have been obliged to acknowledge that there is a *money value* in the relations which the thinker holds to the community around him.

The teachings of our school-days were that organic matter, deprived of the vitality to which it owed its existence, was unstable in its chemical constitution, and the tendency was to go back to the inorganic state through the operations of simple chemical affinities. If this explanation was not clear to our minds, and the fact was referred to that the western hunter who supplied himself with food for the winter by exposing his fresh-killed buffalo meat to the action of the sun and air that swept over those arid plains, did so in direct contradiction to these teachings, to clinch the seeming loose joints in this argument, we were informed that the rule or law was that "the soft parts of animal bodies were especially liable to change after death"; while the exception in the case of the hunter was simply on account of the dryness and great purity of the air. This much was true, but why this air was pure our teachers knew not, and up to within a few years we all have been content with this explanation. We say that it is one of the laws of nature for butchers' meats and vegetables to putrefy and decompose, for milk to turn sour, and the juice of fruits to ferment, and the fruits themselves to decay. And with scrupulous care and large outlays of money, we have sought out many inventions to avoid these results. A pile of green herbage heats and rots, and wood exposed to moisture gradually loses strength and disappears to help form vegetable mould.

A large part of what we call the physical phenomena of this world is largely made up of these various changes; but they are going on so constantly, silently and abundantly about us, that we rarely notice or stop to consider the causes which produce them. As these changes have gone on in the past, we are led to conclude that they will continue. We just as much expect fresh meat will spoil in summer as we do that one season will follow another in regular succession. The wine-maker has no doubt about the fermentation of the juice of the grape, the brewer of his wort, or the baker of his dough, though neither the one nor the other may stop to consider the philosophy of the phenomena with which they are respectively confronted. They hav-

ing ascertained by experiment the governing conditions, proceed with the confident assurance of "what has been, will be."

When we say that "dead organic matter has in itself no such tendency to spontaneous change, that, subject, as in nature generally, to all the activities of *pure air* and *pure water*, and to these alone, whatever the temperature, dead fish and flesh will not become ill-scented or putrid, that milk and blood will not change from the condition they have when drawn from the living animal, that a heap of green or wet grass will not heat and rot, that moist wood will remain as durable as granite, and that the substances of our own bodies after life has departed, are as incorruptible as gold."

These words, to you who hear them for the first time, seem foolish, and upon the face of them absurd; yet, this is the teaching of science, and is the unavoidable conclusion from many instructive experiments.

To-day, any one who will visit the laboratory of Von Recklinghausen, will see blood there, four and five weeks out of the body, preserved in little porcelain cups under glass shades. Not only can you see the amœba-like movements of the white corpuscles, but you will have abundant proof of the growth and development of these corpuscles. You may be shown a frog's heart still pulsating that has been removed from the body for more than a week. You gaze on these results in wonder, and ask whence this mystery—why has not putrefaction set in and obeyed the same laws that it does elsewhere? The professor will tell you there is nothing strange in what you see; the whole mystery consists in keeping the blood free from dirt. He acknowledges frequent failures, but these he attributes to particles of dirt escaping his precautions.

"Progress in science is based on the well-grounded idea that every effect has an adequate cause, and that these causes, in the material world, at least, are subject to undeviating law.

If a body moves, we search for the force which produced the motion, and usually not in vain. If change occurs, a competent agent is at once supposed to be instrumental in its accomplishment. Students of nature are not content with passing anything as mysterious which can be brought within the domain of knowledge, nor with accepting as a fact anything which does not fall *within* the range of *natural causes*."

Posessed of this spirit and provided with the necessary instruments and means, the subject before us could not escape investigation by the quickened intellects of recent times.

"The result is, after much conflict of opinion and difference of interpretation, the established fact that *the natural changes taking place in non-living organic matter are all due to the vital activity of living things.*"

Some of the usual results of life forces may be accomplished in the chemist's laboratory, but the processes and conditions there and in nature are entirely different. Losing sight of this fact oftentimes leads us to false results.

"Life manufactures, and life in turn pulls to pieces and destroys."

Though we may be unable to tell what this life is, or to what its particular powers are due, we can know and study its effects, and these are as pronounced and unique in the natural destruction as they are in the natural upbuilding of organic matter. In this work of destruction, the low microscopic organisms are by no means alone. Every living creature is continually destroying itself, reducing, through its physiological and normal processes, the solid parts to liquids and gases, from the organic to the inorganic. This is the waste which all plants and animals suffer as long as life continues. After death waste goes on in a different way, through the physiological and normal activities of other living beings, and the more noticeably because there is no repair. Among these destroyers are many kinds of animals and plants. All animals are included in the list, and the digestion of food with them is always a work of destruction.

But it is to the *fungi* that we must look for the principal agents of the plant kind, which act as pure destroyers of organic matter. These degraded plants live solely on the accumulated and organized products of other plants and animals, assimilating a portion for the architecture of their own bodily structure, and exhaling another very considerable part as waste, in one shape or another, but ultimately as carbonic acid and water—two prominent ingredients in the original nutrition of green-leaved plants.

An old log in the woods, having no tendency to decay, resisting much better than iron the slow corrosion of the oxygen of the air, tumbles to powder under the digestive power of insects, toadstools, and bacteria, each working differently, but accomplishing nearly the same results. Among the destructive alterations of organic matter, those known as fermentation and putrefaction are peculiarly the effects of certain species of low plants. Because they are so minute, they are not commonly known to be present; hence, the popular idea that the processes are spontaneous, due to the nature of the material in which they occur.

If yeast is not added to the saccharine fluid, but is separated from it by a filter of porous earthen ware, the saccharine fluid will not ferment, although the filter allows the fluid part of the yeast to pass through into the solution of sugar. If the saccharine fluid is boiled so as to destroy the efficiency of any yeast it may accidentally contain, and then allowed to come in contact only with such air as has been passed through cotton-wood, it will never ferment. But if it is exposed freely to the air, it is almost sure to ferment sooner or later, and the probability of its so doing is greatly increased if there is yeast anywhere in the vicinity.

These experiments prove: (1), That there is something in the yeast that provokes fermentation; (2), That this something may have its efficiency destroyed by a high temperature; (3), That this something consists of particles which may be separated from the fluid which contains them by a fine filter; (4), That these particles may be contained in the air, and that they may be strained off from the air by causing it to pass through cotton-wood. Let us examine this yeast in its quantity before and after fermentation. The brewer introduces, say ten pounds of yeast; he collects forty or it may be fifty pounds. The yeast has therefore augmented from four to five fold during the fermentation. Shall we conclude that this additional yeast has been spontaneously generated by the wort? Are we not rather reminded of that seed which fell on good ground? This notion of organic growth is more than a surmise, for beneath the powers of the microscope we can see it budding and sprouting before our eyes. The augmentation of the yeast is thus proved to arise from the growth of a minute plant called *torula*. Spontaneous generation is therefore out of the question. The brewer deliberately sows the yeast plant, which grows and multiplies in the wort as its proper soil.

But says one, who has followed us thus far, the fermentation of the grape juice is spontaneous—no seed sown there, what can you say about spontaneous generation here?

Let us look at the facts. The wine-maker does not, like the brewer and distiller, deliberately introduce either yeast, or any equivalent of yeast, into his vat; he does not consciously sow in them any plant or the germ of any plant; indeed, he has been hitherto in ignorance whether plants or germs of any kind have had anything to do with his operations. Still, when the fermented grape juice is examined, the living *torula* concerned in alcholic fermentation never fails to make its appearance. How is this? If no living germ has been introduced

into the wine-vat, whence comes the life so invariably developed there? You may be disposed to reply, with Turpin and others, "that in virtue of its own inherent powers, the grape juice, when brought into contact with the vivifying atmospheric oxygen, runs spontaneously and of its own accord into the low form of life." We have not the slightest objection to this explanation, provided proper evidence can be adduced to support it. But the evidence snaps asunder under the strain of scientific criticism, and we are obliged to look for some other answer to this question. What, then, is the decision of experiment in reference to the life in the wine-vat? Take a quantity of the clear filtered "must" of the grape, boil so as to destroy such germs as it may have contracted from the air or otherwise. In contact with germless air, the uncontaminated must never ferments. All the materials for spontaneous generation are there, but so long as there is no seed sown, there is no life developed, and no signs of that fermentation which is concomitant of life. Nor is it necessary that we should use a boiled liquid. Nature has so sealed the juice of the grape by its own skin, that it is safe against contamination from without.

Pasteur has extracted from the interior of the grape its pure juice, and proved that, in contact with germless air, it never acquires the power to ferment itself, nor to produce fermentation in other liquids. It is not, therefore, in the interior of the grape that the origin of the life observed in the vat is to be sought. What, then, is its true origin? This is Pasteur's answer, which his well-proved accuracy renders worthy of all confidence:

At the time of the vintage, microscopic particles can be observed adherent both to the outer surface of the grape and to the twigs which support it. Brush these particles into a capsule of pure water, it is rendered turbid by the dust. These minute particles, when examined by the microscope, present the appearance of organized cells. If, instead of receiving them in water, we brush them into the pure inert juice of the grape, and examine this juice forty-eight hours after, we shall find our familiar *torula* budding and sprouting, the growth of the plant being accompanied by all the other signs of active fermentation. What is the inference to be drawn from this experiment? Obviously, that the particles adherent to the external surface of the grape include the germs of that life which, after they have been sown in the juice, appear in such profusion. The ferment of the grape clings like a parasite to its surface, and the art of the wine-maker, from time immemorial, has consisted in bringing—and, it may be added, ignorantly

bringing—two things thus closely associated by nature into actual contact with each other. For thousands of years, what has been consciously done by the brewer has been done unconsciously by the wine-grower. The one has sown his leaven just as much as the other. Nor is it necessary to impregnate the beer wort with yeast to provoke fermentation. Abandoned to the contact of our common air, it sooner or later ferments; but, the chances are that the product of that fermentation, instead of being agreeable, would be disgusting to the taste. By a rare accident, we might get the true alcoholic fermentation, but the odds against obtaining it would be enormous. Pure air, acting on a lifeless liquid, will never provoke fermentation; but our ordinary air is the vehicle of numberless germs which act as ferments, when they fall in appropriate infusions, some producing acidity, others putrefaction or alkalinity. The germs of our yeast-plant are also in the air, but so sparingly distributed that an exposed infusion, like beer-wort, is almost sure to be taken possession of by foreign organisms, and the life of the brewer is a constant warfare against these objectionable ferments.

You can understand from this how easy it is to fall into error in studying the action of any one of these ferments. It is only by the experimenter availing himself of every means of checking his conclusions, that he can walk without tripping through this land of pitfalls. Let us fix our attention more particularly upon the growth and action of the true yeast-plant under different conditions. Let it be sown in a fermentable liquid, which is supplied with plenty of pure air. The plant will flourish in the aërated infusion and produce large quantities of carbonic acid gas. The oxygen thus consumed by the plant is the free oxygen of the air, which we suppose to be abundantly supplied to the liquid. The action, so far, is similar to the respiration of animals, which inspire oxygen and expire carbonic acid. If we examine the liquid when the vigor of the plant has reached its maximum, we hardly find in it a trace of alcohol. And could every individual yeast-cell seize, without any impediment, free oxygen from the surrounding liquid, it is certain that it would cease to act as a ferment altogether. This experiment leads us to ask, what, then, are the conditions under which the yeast-plant must be placed so that it may display its characteristic quality? Consider the beer in its barrel with a single small aperture open to the air, through which it cannot imbibe oxygen but continually pours forth carbonic acid gas. Whence comes the volume of oxygen necessary to the production of this latter gas?

The small quantity of atmospheric air dissolved in the wort, and overlying it, would be totally incompetent to supply the necessary oxygen. The only way left for the plant to provide for its respiration the needed oxygen, is to wrench it from surrounding substances in which the oxygen exists—not free, but in a state of combination. This it does by decomposing the sugar in the solution in which it grows, producing heat, and breathing forth carbonic acid gas, and one of the liquid products of this decomposition is our familiar alcohol. The act of fermentation, then, is the result of the effort of the little plant to maintain its respiration by means of combined oxygen, when its supply of free oxygen is cut off; or, as Pasteur defines it, "*life without air.*" But here we must take heed lest we fall into a possible error.

"It is not all yeast-cells that can thus live without air and provoke fermentation. They must be young cells which have caught their vegetative vigor from contact with free oxygen. Under these new conditions its life, *as a plant,* will be by no means so vigorous as when it had a supply of free oxygen; but its action, *as a ferment,* will be indefinitely greater."

Liebig, in his studies on fermentation, assumed that yeast acted in virtue of its *organic* character.

Ludersdorf concluded that it acted in virtue of its *organized* character, and proceeded to show it by the following experiment: He destroyed the cells of yeast by rubbing them on a ground glass plate. Here the life was destroyed, but the chemical constituents remained the same; but its power to act as a ferment totally disappeared.

Does the yeast-plant stand alone in its power of provoking alcoholic fermentation? In answering this question, we have occasion to marvel at the sagacity of observation among the ancients to which we owe so vast a debt. Not only did they discover the alcoholic ferments of yeast, but they had to exercise a wise selection in picking it out from others, and giving it special prominence. Place an old boot in a moist place, or expose common paste or a pot of jam to the air; it soon becomes coated with a blue-green mould, which is nothing else than the fructification of the little plant, *pencillium glaucum.* Do not imagine that this mould has sprung spontaneously from boot, or paste, or jam; its germs, which are abundant in the air, have been sown, and have germinated in as legal and legitimate a way as thistle-seed wafted by the wind to a proper soil. Let these same minute spores of *pencillium* be sown in a fermentable liquid, which has been previ-

ously boiled so as to kill all other spores or seeds which it may contain, let pure air have access to the mixture, the *pencillium* will grow rapidly, striking down deep into the liquid its long filaments, and fructifying at its surface. If we test this infusion at various stages of the plant's growth, you will never find in it a trace of alcohol. But forcibly submerge the little plant, push it down deep into the liquid, where the quantity of free oxygen that can reach it is insufficient for its needs, it immediately begins to act as a ferment, supplying itself with oxygen by the decomposition of the sugar, and producing alcohol as one of the results of the decomposition. Many other low microscopic plants act in the same way.

The transformation of wine into vinegar is a phenomenon long known and utilized. From a chemical point of view, this transformation is due to the oxidation of the alcohol. The agent of this oxidation is a micro-organism called *mycoderma aceti*. It belongs to the group of the *micro-bacteria*, and its development presents some interesting peculiarities, which we give in the language of M. Duclaux: "These little beings reproduce themselves with such rapidity that by placing an imperceptible germ upon the surface of a liquid contained in a vat having a surface of one square meter, in round numbers, nearly 1,600 square inches, we may see it covered in from twenty-four to forty-eight hours with a uniform velvety veil. This veil is well known to every one as the *mother of vinegar*, and its rapid production is worthy of note. If we estimate that there are three thousand cells in a square millimeter, which is below the truth, this will give for the vat three thousand milliards of cells produced in a very short time."

The *mycoderma aceti* is not always the same. Usually it forms upon the surface of a liquid a soft-looking veil, smooth at first, then wrinkled, which is with difficulty submerged and moistened. If we plunge a glass rod into the liquid, it pierces this veil, and, on withdrawing it, a portion remains attached to the rod, and the opening made immediately disappears, being occupied by the veil which seems never to have room enough in which to extend itself. We frequently find another form of veil, dryer, firmer, sometimes showing prismatic colors. This veil does not wrinkle, but is covered with crossed undulations, having sharp edges, which recall the surface of a honey-comb. Sown upon the surface of various liquids, it reproduces itself identically, and it is difficult not to consider it a different form of the preceding. There is still another species producing well-developed veils,

with scarcely any acetifying power, and reproducing itself with this character. These forms are difficult to distinguish the one from the other, because of their minuteness. We may say, however, that the second is smaller than the first, and the third more attenuated than either of the others.

We have said that our air is full of germs differing from the alcoholic leaven, and sometimes seriously interfering with it. So we find it with the acetic fermentation. The liquid in which this ferment is cultivated should be a little acid, for, in this microscopic garden we find plenty of weeds ready to rise up and choke out the flowers. The weed in this case is an entirely different organism—a species of saccharomycite, known as *the mycoderma vini*, which has an action quite different from the M. aceti. It is a consumer of the alcohol, transforming it into water and carbonic acid. It also consumes the acetic acid. By making the liquid acid in which acetic fermentation is wished to take place, we render the conditions of growth unfavorable to *mycoderma vini*.

Please to notice again that observation has guided men right in the selection of this ferment, and the proper method to combat its enemies, long before science could aid them in the least. Observation has taught us that we must sow *M. aceti*, or we should see the *M. vini* develop in its place, as the germs of the latter are more widely diffused in the air.

Saccharine fluids, left to themselves, are susceptible of divers fermentations, which may occur separately or simultaneously. Those which have been best studied are three: The lactic, the butyric, and the viscous fermentations.

Lactic Fermentation: If we expose milk to the action of the air, it will after a time turn putrid or sour, separating into clot and serum. Place a drop of such milk under your microscope, and watch it closely. You see the minute butter globules animated by that curious quivering motion, called the Brownian movement. Do not tarry over this too long, for it is another motion that we have now to seek. Here and there you observe a greater disturbance than ordinary among the globules. Keep your eye on the place of tumult and you will see emerging from it a long eel-like organism, tossing the globules aside, and wriggling its way more or less rapidly across the field of the microscope. Part of the change wrought in the milk is due to this organism, which, from its motions, receives the name, *vibrio*. This bacterium, according to Pasteur, develops in sweet liquids, in which

it causes the formation of acetic acid, and in milk the coagulation of the casein. In curdled milk, you find other organisms, small, motionless, and usually linked together like beads on a string. Under the influence of this bacterium (ferment lactique of Pasteur), glucose, and the substances susceptible of furnishing it (such as mannite, malic acid, etc.), are transformed into lactic acid. The chemist will tell us that this is nothing but a molecular change, lactic acid having the same composition as glucose. Taken in mass the lactic ferment resembles beer yeast—its consistence a little more viscous, and its color a little more grey; but, under the microscope, the aspect is quite different. An interesting point concerning this fermentation is the action of acids upon the bacteria which produce it.

As soon as the medium becomes acid, even by the lactic acid produced, the transformation is arrested. It resumes its course if chalk or carbonate of soda is added to the liquid. The most suitable temperature is 95° Far. (35° Cent.) But milk may become putrid without becoming sour.

Examine putrid milk microscopically, and you find it swarming with shorter organisms, sometimes associated with the vibrios, sometimes alone, and often manifesting a wonderful activity of motion. Keep these organisms and their germs out of your milk, and it will never putrefy. Heat kills the bacteria, cold numbs them. The housekeeper, though ignorant of these little organisms, heats the milk, or places it in contact with ice to extend its period of sweetness and postpone the evil day. We often see this fermentation occur in beef juice or in sour starch water; it must play a part in the formation of sour krout, and intervenes very certainly, and perhaps more than the alcoholic fermentation, in the preparation of bread. It very easily invades beer, because of its slight acidity. This fermentation, of which we know so little, merits to be better studied.

The Butyric Fermentation is in fact always preceded by a lactic transformation, and it is by an ulterior modification that the lactic acid produces the butyric acid. The organism which produces it is a bacterium very nearly allied to *bacillis subtilis*. This fermentation resembles putrefaction in a great many particulars; some authors include it under the same head.

Viscous Fermentation: Wines often change so they contain a mucilaginous substance and mannite. This viscous matter has the same composition as gum or dextrine ($C_6H_{10}O_5$), at the same time disengaging carbonic acid gas. In the fermenting liquid we find an

organism which is not yet sufficiently studied. These are little chaplets of small spherical bodies, of which the size varies sensibly, according to the kind of wine attacked by the malady. We have united together the lactic, butyric, and viscous ferments, because all three manifest themselves in the same liquids, and because they have for effect the transformation of glucose.

Nitrification and Putrefaction: In the fermentations which we have just passed rapidly in review, we have thus far been able to study at least the chemical action of the different organisms. We are now about to find ourselves in presence of phenomena far more complex. We will have to consider a great number of these vegetables at work, without it being possible to assign to each its rôle, or to say what is its function. The agent of the nitric fermentation has not as yet been seen, and it is only by analogy that we class this nitrification with the true fermentation. It is only because of the obscurity which still exists in regard to a great number of peculiarities of these two phenomena that we have united them in the same study. From the point of view of the circulation upon the surface of our globe of the elements essential to the constitution of organisms, they play an analogous *role*, although opposite the one to the other.

Consider nitrogen in plants. This element, of which the atmosphere is the reservoir, does not enter directly into combination, as does oxygen with the other elements which, with it, are to constitute the immediate principles of the tissues. The chemical properties of nitrogen may be characterized in a few words: Great resistance to entering into combination when it is free, and great facility, on the contrary, in passing from one combination to another when once it has associated itself with other elements.

Whence comes the ammonia which is found in the sea, in the clouds which come to us from equatorial regions, and in the dust of the air? The only known source is the fermentation of organic matters out of reach of the oxygen of the air. It is to this sort of fermentation that we owe the formation of peat, and the masses of combustible minerals which have formed during nearly all the geological periods. When we expose an organic liquid to the air, we see this sort of fermentation develop itself; but only in the inferior part of the liquid, the oxygen which is dissolved near the surface being arrested in the superficial zone, where a very different fermentation occurs. The one at the surface is essentially oxidizing; the material is almost completely burnt, forming water and carbonic acid, while at

the inferior part, on the contrary, a reduction is produced so energetic that hydrogen is disengaged. The metallic sulphites are there transformed into sulphates, and even crystals of sulphur are sometimes found in the organisms of thermal sulphur waters, where they constitute flocculi and play a great rôle in the elimination of sulphur and the disengagement of sulphuretted hydrogen in these waters. Vegetables do not absorb nitrogen under the form of ammonia, but under the form of nitric acid.

How is this transformation of ammonia into nitric acid effected? Repeated observation has confirmed the fact that in the phenomena of destructive putrefaction, nitric acid, far from being produced is, on the other hand, reduced to the state of nitrous acid; and in the putrefactions essentially oxidizing, produced by *pencillium glaucum* and others of this species, there is no formation of nitric acid. Nitrification is a special phenomenon which takes place in every soil sufficiently loose to permit a free circulation of air, and of which the agent is a micro-organism. This organism has not yet been perceived, it is true; and it is evident that it would be difficult to seek and observe, because of its peculiar situation. But the action of chloroform upon nitrification tends to prove that the agent of this process is truly an oxidized ferment. This anæsthetic suspends nitrification, and seems even to kill the ferment. This nitrification, or rather the ferment which causes it, can only take place during summer temperature, and the observing farmer, as he stirs his soil to admit the needful oxygen freely, just as we stir the fire in winter to admit it, learns to perceive when his soil is in a lively "rising" state of fermentation almost as well as his wife perceives when her dough is working aright, although hitherto science had no explanation to offer of what the practical farmer was sure that he observed. We may distinguish in the agents of putrefaction, or more generally of fermentation, two groups of micro-organisms—one oxidizing, the other reducing. The first are observed upon the surface of liquids undergoing putrefaction. We notice a great number of forms, *bacterium termo*, *monas crepusculum sirillum*, etc. We ought also to include *mycoderma aceti* which, like the other, vegetates on the surface of liquids. The second, on the contrary, in the interior of liquids or of fermentable bodies—they are analogous to the butyric and lactic ferments. These low organisms, which one might be disposed to regard as the beginnings of life, were we not warned that the microscope, precious and perfect as it is, has not the power to show us the real beginnings of life (for evidently there is

a great unknown world of minuteness still beyond its highest powers), are by no means purely useless or purely mischievous in the economy of nature. They are only noxious when out of their proper place. They exercise a useful and valuable function as the burners and consumers of dead matter, animal and vegetable, reducing such matter, with a rapidity otherwise unattainable, to innocent carbonic acid and water. Futhermore, they are not all alike, and it is only restricted classes of them that are really dangerous to man. One difference in their habits is worthy of special reference here. Air, or, rather, the oxygen of the air, which is absolutely necessary to the support of the bacteria of putrefaction, is absolutely deadly to the vibrios which provoke the butyric acid fermentation. This can be illustrated by any one having a microscope. A drop of the liquid containing these small organisms is placed on a slide, and on the top place a very thin cover glass; for, to see them, it is necessary that the object glass of the microscope should come very close to the organisms. Round the edge of the circular plate of glass, the liquid is in contact with the air, and incessantly absorbs it, including the oxygen. Here, if the drop be charged with *bacteria termo*, we have a zone of very lively ones, greedy of oxygen, and appropriating it to their use, while through this living zone the vivifying gas cannot penetrate to the center of the film; and here we find in the middle the bacteria dead and dying. If a bubble of air chance to be inclosed in the film, round it the bacteria turn and wabble, until its oxygen has been absorbed, after which all their motions cease. The reverse of this occurs in the vibrios of butyric acid. In their case, it is the peripheral organisms that are first killed, the central ones remaining vigorous, while ringed by a zone of dead. It was while observing these differences of deportment that the thought of life without air and its bearings on the theory of fermentation flashed on the mind of Pasteur.

To some minds, the question of putrefaction being the results of these micro-organisms, is by no means clear; they may concede that they have an important part to play in some of the fermentations named; but we oftentimes find them asking, How do we know that these organisms are not the mere accompaniers of this condition?

In the year 1837, Schwann, of Berlin, announced the important result that when a decoction of meat is effectually screened from the ordinary air, and supplied solely with calcined air, putrefaction never sets in. He therefore affirmed putrefaction to be caused by something in the air, which could be destroyed by a sufficiently high tem-

perature. And to-day the fermentation of fruit juices has been brought under control in every household in the land by a knowledge, consciously or unconsciously, of this deduction of Schwann's; they have learned that a heat of 130° Far. is sufficient to destroy the germs in wine, cider, etc., and that, if they are sealed up while every part is at or over that temperature, without the possibility of a single one of the swarming germs being sealed inside, without having been subjected to that heat, the article so secured will remain unchanged as long as the sealing remains entire.

In verifying these experiments in putrefaction, Spalanzani melted the neck of the little flask together during the cooking. The result was that the material enclosed in the flask remained for all time without putrefaction. Then came the assertion that the materials enclosed in the flask of Spalanzani remained fresh, not because there was no bacteria in them, but rather because there was no oxygen present; for it is certain that, by cooking, the air is expelled and the entrance of new oxygen is rendered impossible by the melting of the neck of the flask. In order to refute this objection, Dr. Schwann modified this experiment by blowing air into the flask through a red-hot tube previous to melting its neck. By this process, all the living germs were destroyed.

Dusch, in 1854, seeking a more convenient method, plugged the neck of the flask with cleansed cotton, by which the air was filtered from germs as it entered the flask.

In 1863, Pasteur became interested in these experiments, and reasoning from the fact that the germs contained in the air, following gravitation, settle down in open vessels, after boiling his infusions, bent down the neck of the flask horse-shoe shape, without melting it. The results of these methods were always the same; the materials enclosed never fell into putrefaction. From these experiments, often repeated with the same results, it has been concluded that putrefaction does not take place if no bacteria are present; and, on the other hand, that the multiplication of bacteria ceases as soon as the substances capable of producing putrefaction are destroyed. Therefore, bacteria are not the chance companions but rather the cause of putrefaction, and Cohn, in the light of the foregoing experiments, defines putrefaction to be "*a chemical process excited by bacteria*." Death does not, as is generally supposed, cause putrefaction, but rather it is caused by the life of these invisible organisms.

The whole arrangement of nature is based on this, that the body in

which life has become extinguished succumbs to dissolution in order that its material may become serviceable to new life. The amount of material which can be moulded into living beings is limited; the same particles of material must ever be converted from dead into living bodies in an eternal circle. If the wandering of the soul be a myth, the wandering of matter is a scientific fact.

What, then, would be the result if there were no bacteria? The material embodied in animals and plants of one generation would, after their decease, remain bound as the chemical combinations in the rocks; new life could not develop, because there would be lack of body material. Since bacteria cause the dead body to come to the earth in rapid putrefaction, they alone cause the springing forth of new life, and thus make the continuance of living creatures possible. The wonderful fact that putrefaction is a work performed by bacteria does not stand alone; we have seen that there is an entire series of chemical changes which are produced by these and similar microscopic forms. The great bulk of the plant world derives its nourishment from inorganic matter; the plant, taking the crude materials as they are furnished in the salts of the soil, elaborates them in its cells, and forms from them its cellulose, its starch, its chlorophyll and its diastaste.

On the other hand, animal life depends in as great a degree upon materials which have been already elaborated by vegetable chemism. It depends mainly upon the plants, starch, and gluten, in one shape or other. Either taking them direct, or, as in the case of carnivorous animals, simply taking the results of their assimilation by others, how long could this double drain on nature continue with no return? The farmers, many of them rather late in life, have learned that they cannot demand food from the soil without rendering some return. In their ignorance, our ancestors for years defrauded the earth which gave them bread, and we are just learning that we must in some shape or other, by the use of fertilizers, pay back the debt we owe to mother earth, or lack a harvest.

What are these fertilizers? Nothing more than materials which have, by the aid of bacteria, completed the circle of nutrition—materials which have been taken from the earth in the first place to form plant tissue, this in its turn has been appropriated by the animal economy, and these very animals yield themselves up at last, in the shape of phosphates, etc., to the soil which takes back its own. Thus we complete the circle; here we find the life-work of bacteria placed

by nature everywhere. We can well call them omnipresent—standing on the picket-line between live and dead matter, sentinels of nature, ever watchful to cast back into life's domain the materials for its ceaseless, ever changing tide.

Thus hastily have we reviewed this subject—not as an investigator, but, rather, as a gleaner from the teeming fields—a gatherer of stray straws that have been left by those bold spirits who are engaged in gathering the great mass of facts, that now show such an abundant harvest for science, which, in being left, has furnished us an index by which we could refer to their work, hoping that by the glimpses caught from the gleanings, you may be induced to become workers in this or kindred fields, thus adding by your labors to the general stock of scientific knowledge.

"EASTERN TRUTH-SEEKER."

An anonymous, who styles himself "An Eastern Truth-seeker," publishes an article in the Ohio State Journal, full of sneaking side kicks at somebody who is never mentioned. The "Truth-seeker" shows occasionally a glimpse of light. The passage, "A man who has the courage of his convictions is always an object of admiration," is very good, and if "Truth-seeker" means what he says, we can do nothing better than advise him to carry out the axiom. The gentlemen referred to by "Eastern Truth-seeker," who by accident are connected with an eastern periodical, are just such men, who have the courage of their convictions, and deserve certainly the reward mentioned. The "Truth-seeker" informs us that "facts are facts." He has gained certainly a great deal of truth, if he has come to that conclusion; but the arrangement of facts in logical order is no natural sequel whatever; it takes brains to do that. The facts about the planets were known many years before Kepler, who, by the way, did not "divest the *Copernican* system of the universe of its absurdities." "Truth-seeker" seems to have made a confusion of the Copernican and the Ptolomean systems. The Copernican system did not contain "absurdities," only inaccuracies. Every young student of a high school knows that the Copernican system of the universe refuted the absurdities of the Ptolomean system, and Kepler was only the calculating astronomer, who applied figures to the general theories of Copernicus. Copernicus and Ptolomy ought not to be confounded by "Eastern Truth-seeker."

How one can speak of flask experiments as being as near the natural condition of the mouth as possible, or, as being worth anything, requires an "Eastern Truth-seeker" to understand. *Flask experiments are worthless;* let us keep that in mind. There is not the faintest resemblance between the tooth in the flask and the tooth in the jaws, even the tooth is not the same. We do not dispute the superiority of Dr. Miller's work; he has done a very great thing indeed, and his experiments, aided by the microscope, and the chemical authorities of Germany, have more than sufficiently established certain facts. These facts we all agree upon; we differ only in their explanations. But Dr. Miller has not disproved facts that were established before him. "Eastern Truth-seeker" claims he can prove by his microscope—that famous microscope!!—that the softened dentine near the sound portion of the tooth is not dead, if that tooth has a live pulp; that is at least the plain statement that we can make uot of ten lines of words. Well, let him do it, and show something! The dental world will be thankful and no damage done. "Truth-seeker" is very modest in his desire for common sense. He wants only about "four and one-half grains." Why, for mercy's sake, we can let him have that without difficulty, and we will give him a printed instruction how to use it, together with his microscope. We would still have enough left to supply seven thousand more to come at the rate demanded.

COMMON SENSE.

"Every time one breathes, over five hundred millions of air-cells are inflated, and five hundred millions of networks of capillary vessels send their blood-disk along, purified, vitalized, dancing for joy."

"He who will look steadfastly out into the world, will perceive himself surveyed by a great eye returning his stare."

"Gravitation is the Holy Ghost of the material world."

EDITORIAL.

IS A "DEAD TOOTH" DEAD?

From an article in the July number of the *Ohio State Journal*, by Dr. Frank Brewer, of San Francisco, we make the following selection:

"Now, then, let us turn our attention to a *dead* tooth, and ascertain the truth or denial of the claim that its corpse is but a *peg* stuck in the jaw. We first, then, present and answer the following question: Do the canaliculi or dentine tubular tissue cease their vitality and life simultaneously with the death of the *nerve when devitalized?* We reply, no! provided the same has not been paralyzed with arsenic or other escharotics. Indeed, so excessive have we found the sensitiveness in certain cases, or those where the nerve organ had become calcified through abrasion, that an obtunder was demanded in their reduction. In one case at Santa Barbara, and which at the time was recorded in the *Missouri Dental Journal*, the sensation was so severe that the contact of the drill made the patient fairly howl, and required several applications of chloride of zinc to reduce it. This sensation was observed not only throughout the zone of calcification of the nerve locality, but embraced all the intermediate area, defining the original nerve canal and cementum. The patient being at the time an invalid, from nervous anomaly, this phenomenon was attributed thereto. But of late we find ourselves mistaken, for two months since an additional case, similar in character—nerve calcified—came within our hands, whose constitutional diathesis proved the very opposite of the previous case. This one, also, was found excessively sensitive, and required several applications of a cauterant to control. Numerous cases of teeth with nerves calcified, and manifesting more or less sensibility, have we operated upon. In cases of *spontaneous* devitalization, uninfluenced by any original accident of mechanical injury, this phenomenon is again verified, and the sensation will be observed located at a position contiguous to the cemental structure. Again, it may be recognized in cases of gaseous encroachment within. A tooth laboring under gas encroachment, and with no abscess or sinus, as soon as the crown is opened, relief seems almost instantaneous, especially during the latter condition, and as well as at others, *thermal* influences are quite readily observed, and the *passage* of the *finger nail* upon the cervix of either labial or buccal surface of the

tooth, the same is noticeable. We have retained the same vitality by withdrawal of a nerve following its *anæsethetization*, by which no *excitation followed* at any point along its course, especially necessary at the apices. Hence, if this all be true, from *whence* cometh the nourishment *sustaining* this neural *vitality?* We can only reply, from the *periosteum*, aided principally and protected by the peculiar conformation of the *vascular* tissue of the *cementum* and *Nasmyth's* membrane."

DR. BOYNTON'S PAPER.

In this number of the JOURNAL our readers will find the paper read by Dr. Boynton at the American Dental Convention at Saratoga last August. The object of the paper is to give the profession a *resume* of the subject of Fermentation and Putrefaction as it is now looked upon by those scientists who have made this subject a study from the point of view of the germ theory.

The Doctor, in his introductory remarks, disclaimed any attempt at originality, acting only as a "middle man in science," drawing freely from the literature of the subject, aiming only to give a clear and comprehensive view of the subject as it is now understood.

At first, it may seem to have little connection with dentistry; but, to those who feel that the germ theory of dental caries is true, it is full of interest. We talk learnedly of fermentation and putrefaction often as though the terms were interchangeable, but we find one precedes the other; and here comes in the question of treatment. If fermentation is the first step, what measures can we take to stop these ferments? Checking the fermentation checks further inroads which lead on to caries, and with this we are brought face to face with the question of antiseptics and antiseptic treatment for diseases of the oral cavity.

For our own part, we had rather the Dr. would have given us a few hints on these subjects from his own note-book rather than to have drawn so largely on Tyndall, Pasteur, Magin. Cohnn, and, in fact, all that have written on the subject. He has given us facts as they are now believed to exist; this is all right, but to some of us in daily practice it would have seemed a little more practical to have told us what was to be done by way of treatment.

We should not be so pronounced in our opinion if we had not been favored for years with the doctor's acquaintance, and know that for fifteen years, at least, he has been a firm advocate of the germ theory

and has been on the lookout for facts, and from what we know of his note-book we can only wish he had given us a little more of the practical side. We hope, on reflection, he will conclude to give the readers of the JOURNAL a peep into that note-book, especially the part relating to antiseptics.

As it is, the paper has a value in enlarging our ideas of the extent to which we are indebted to micro-organisms for the production of a large share of the physical phenomena of this world.

THE NEW ENGLAND DENTAL SOCIETY.

The New England Dental Society will meet at Providence, R. I., on the 4th and 5th of October. Arrangements have been made for half-fare trip tickets on the Boston and Providence railroad, and also on the New York, Providence and Boston, and a reduction from regular fares on the Worcester and Providence road. The Narragansett Hotel—headquarters—offer reduced rates. Prof. Garretson will be present and deliver an address and give a clinic. A most excellent meeting is assured, and every dentist in New England should be present.

CONNECTICUT VALLEY DENTAL SOCIETY.

The annual meeting of this Society is to be held at the Haynes House, Springfield, Mass., on Wednesday and Thursday, November 7th and 8th.

PEARSON'S DENTISTS' APPOINTMENT BOOK.

We have to thank the publishers for one of "*Pearson's Dentists' Appointment Books* for the vest pocket." This is a *model* of an appointment book, and is published by J. L. Brewster, Jr., of the Kansas City Dental Depot, publisher of the Missouri Dental Journal. The author, Dr. R. I. Pearson, is the managing editor of the same Journal.

TO NEW SUBSCRIBERS.

The subscription price of the New England Journal of Dentistry for 1884 will be the same as in the past, viz: $2.00 per year. *Subscriptions received now will not expire till December, 1884.*

DR. KARL BURGER, of Bonn, claims to have discovered the bacterium of whooping cough.

The July number of the Correspondenz-Blatt für Zahnärzte (Dental Exchange), has just reached us. It is a very voluminous quarterly of about one hundred pages. Dr. Kronthal, of Posen, reports a case of destructive periodontitis of all the teeth in the upper jaw occurring in a woman twenty-nine years old.

Dr. Telschow, a very prominent practical dentist of Germany, who is a specialist there in continuous gum work, gives his experience. The paper of Dr. D. D. Smith, of Philadelphia, read at the meeting of the Mass. Dental Society, is reprinted. Dr. Sozinskey, in an article about the lancet and its uses, re-tells the good story that a man of the name of Rodgers, at the court of Charles I., died in his ninety-sixth year in consequence of *teething*. Four teeth were already erupted, and several more were about to erupt, which caused a violent inflammation of the gums, and from that his death. Poor baby! Dr. Truman W. Brophy's (of Chicago) article on caries and necrosis of the jaw, the article of Dr. J. N. Crouse about the methods and materials for preserving the teeth, and of Dr. W. A. Stevens, of Chicago, from the Ohio State Journal, appear in translation. The firm, Ash & Son, of London, controls the monthly, as the "Cosmos" is controlled by S. S. White, etc.

A sad-looking display of "patents revoked" is given at the end of the Journal. The superiority of the American patent law is plainly seen. The German patent law is nothing but a rather mean contrivance to squeeze out of poor inventors more and more tax every year. It starts on the wrong supposition that a patent which does not pay a yearly tax, increased every year, should not be held. This is a very thin sophism. Many of the American patents which finally prove a great benefit to the public and inventor have been of value only after many years of work. So the bicycle patent, which did not pay very much for the first few years. According to the German law, the owner of the patent would have had to pay every year taxes of from fifty to a hundred dollars, or have his patent revoked. This clause of the German patent law makes German patents rather worthless and appears to be on one line with the love of the German political economists for the income tax.

One who uses Robinson's Fibrous Foil for lining vulcanized rubber plates, states that good results are obtained by the following method: After vulcanizing at "320" for forty-five or fifty minutes, run the temperature up to 345 or 350 and hold it there for a few moments. This seems to consolidate the metal lining and forms a better surface.

THE DENTAL MUTUAL AID ASSOCIATION.

We are glad to record the fact that an Association, bearing the above name, is being organized. It is in the hands, at present, of some live men in the State of Missouri, where, by virtue of its "charter," the home office will be located, probably either at St. Louis or Kansas City.

Its purpose is like that of similar organizations chartered by traveling men, railroad men, physicians, etc. We see no reason why the dental profession may not successfully carry out a scheme of this character to the entire satisfaction of all concerned. By the proper operation of such an organization, the families of men who have given the best part of their lives that others may be benefited would thus be saved the embarrassment and humiliation of being placed before the world as absolute paupers. Such cases are not uncommon. It is proposed to carefully guard the Association by such restrictions as may seem necessary. It will be officered by some of the best men in the profession and the membership will be confined to State and local dental societies. Age, health and morals will also be considered. Its operations are expected to extend over the whole country, each State having a board of advisory officers. We hope to be able to give full particulars in our next number.

DEATH OF PROF. T. L. BUCKINGHAM.

Thomas L. Buckingham, M. D., D. D. S., died, at Philadelphia, Sept. 4th, 1883, of softening of the brain, in the sixty-seventh year of his age.

Dr. Buckingham was so well known by the dental profession that an obituary notice is apparently unnecessary. A *son* feels the need of no such notice when a *father* dies; and Dr. Buckingham was one of the fathers of the dental "Israel."

THE LIFE OF MAN.

One of our subscribers sends us the following, clipped from some newspaper:

"Man, born of woman, is of few days and no teeth. And, indeed, it would be money in his pocket sometimes if he had less of either. As for his days, he wasteth one-third of them, and as for his teeth, he has convulsions when he cuts them, and as the last one comes through, lo! the dentist is twisting the first one out, and the last end of that man's jaw is worse than the first, being full of porcelain and a roof-plate built to hold blackberry seeds."

CREMATION in Japan is becoming very general; about 9,000 bodies are disposed of in this way yearly.

SOCIETIES.

THE TWENTY-NINTH ANNUAL MEETING OF THE AMERICAN DENTAL CONVENTION, HELD AT THE TOWN HALL, SARATOGA SPRINGS, N. Y., AUGUST 14, 15, AND 16, 1883.

The morning session of August 14 was mostly given to organization. Rev. Joseph Cary, D. D., was present, and addressed the meeting at its opening.

Congratulatory Address of Dr. J. G. Ambler.

I congratulate you, Mr. President and Gentlemen, on the number convening, and in doing so I beg leave to express the thanks of the committee to our worthy president and secretary for their solicitude in making the preparations for this meeting. I trust that the preparations thus far will meet with your approval, and it is a pleasure and duty of the chairman of the executive committee to do his duty until the closing of the convention, which I trust may be instructive and interesting. It has been my luck to be a co-worker since the commencement. I have seen the convention in its infancy and I have seen it in mature age, have seen it under a cloud, have seen it when its members were few and when they were many; through all the steps it has been my pleasure and luck to have mingled with you. I have found that this organization is independent of all other organizations —additional, but by no means oppositional. The course we have marked out is thoroughly democratic. Other organizations exist by representatives of local societies; we open our doors wide for all. All with clean spirits, to whom no objection can be made, are invited to participate in our discussions, and give us the benefit of their ideas, thus multiplying the information, making each one the recipient of the art of all. I trust that the convention will be replete with representations and practices of modes of operation, and that we will have many, detailing minutely their efforts in what we call incidents of office practice, which will take a prominent part in our proceedings.

Dr. Clark gives his opening address. (See next number.)

The business affairs of the convention are arranged and the meeting adjourned for the afternoon.

Afternoon Session, August 14, 1883.

The first subject is the paper of Dr. Boynton, printed in this number.

Prof. CHARLES MAYR, Springfield, Mass.: The paper of Dr. Boynton presents many very interesting points. Something very new to me was the communication of experiments tending to prove that saltpetre may be due to the action of certain organisms in the decaying inorganic matter. These organisms seem to reach further than we ever thought before; there seem to be many ways that lead to Rome. We all know that alcohol can be made in the most diverse manners; it can be made in our laboratories without any yeast at all, from the pure elements C, H and O, without the intervention of any organized substance, and the alcohol prepared in this way is identical with the alcohol prepared from fermentation. Not only alcohol, but even more complex substances, like organic acid, etc., are made in this way in our laboratories; but if we make them in our laboratories in a certain way, this does not prove that in the body they are made in the same way. Nitric acid, as most of you know, can also be made artificially without any difficulty, by letting an electric spark pass through a mixture of oxygen and nitrogen in the presence of some alkali; the nitric acid combines with the alkali and forms nitrates, but the presence of an alkali is not necessary for the formation of the nitric acid; it will form without it, only if the acid formed is not absorbed, the action of the electric spark soon ceases and only a limited amount can be produced. It would be of little interest should I detail the exact way of making alcohol without fermentation; a pound of this alcohol may practically cost $500, made in the laboratory from H, C, O, but as far as science is concerned, dollars and cents do not play any part whatever; the only question is, that it can be done; many people confound the money part with the scientific point. All are well aware of the way in which acetic acid may be generated without a trace of mycoderma aceti; dilute pure alcohol is dropped on platinum black, and with evolution of heat a part of it is transformed into aldehyde, another part into acetic acid, that is, the acid of vinegar. If one wishes a still better resemblance to the common "old-fashioned" cider vinegar, one can take a little mud from the street and throw it into the solution, together with a few rotten apples, the flavor and appearance can be imitated to identity; popular ignorance is still in favor of the cider mud.

Dr. F. Y. CLARK: At the Springfield meeting it was stated by Drs. Miller and Barrett that teeth filled out of the mouth will remain for ages free from decay; I have made experiments and find that I cannot produce any chemical action of bacteria without moisture, and I

think that it applies not only to the tooth substance but to all animal tissues. It is absolutely necessary that there must be moisture; fill a tooth, exclude all moisture, free it from all its mesh-work, and dry it, and I doubt very much whether there be ever any bacterial action under the filling. I remember some time ago, when I began practicing, there were mounds in Florida; I would dig, and every now and then I would come across teeth; every other particle of the body was gone. Of these mounds the Seminoles knew nothing, they were very old. All you could find by going down six to eight feet was a clump of teeth, and where you would find one you would find another, showing that persons were buried there. After six or eight months I tried to ascertain how the men were buried. I worked in one mound very carefully, and finally came to the roots of teeth. I removed the soil around these roots; I came to one root and then another, until I came to the roots of fourteen teeth upward; I kept on removing the soil, until I found the fourteen teeth antagonizing with the fourteen in the superior maxilla; that was a very important discovery, showing that the person was buried erect, and that has caused a great deal of discussion among scientists in regard to the mound-builders and those teeth in the mounds. Where there was any moisture, no remains could be found; where the soil was perfectly free from moisture, those teeth could be found in any state of preservation. One set I retained for a long time. Since the experiments of Dr. Miller, told at Springfield, I have filled teeth out of the mouth, leaving them moist, and I find that there is a micro-organic action, even out of the mouth; the deportment of natural teeth out of the mouth and in the mouth are two very different things; in the mouth we have all the natural elements for producing the reaction; we have every facility for the production of germs.

In regard to the paper of Dr. Boynton, I can fully endorse what he said in regard to fermentation. In regard to putrefaction, I can say there is no putrefaction without bacterium termo; wherever putrefaction is going on, this organism is found, along with other organisms, but bacterium termo is the one which has most to do with putrefaction. And wherever putrefaction commences, in all examinations that I ever made, I could find no organism at work but bacterium termo. It will be noticed in all putrefying fluids, and when putrefaction ceases, they can no more be found.

Dr. RICH: Dr. Clark has said that teeth will not decay when dry; one thing occurred to me while he was speaking. Supposing a filling

was made of gutta-percha, very tight, and left in the mouth for six months or a year, you then apply the rubber dam before taking out the filling, you dry the tooth all around and allow no access of moisture, you then remove the filling and fill it again as perfectly as possible, would we have any decay?

Dr. CLARK: There is always a fight going on between the inner and outer forces. Right there is what we call protoplasm; I call it bioplasm. It is a part of the tooth substance, it is the mesh-work of the tooth; distinct fibers have never positively been discovered; it contains a certain amount of moisture; it is a clear transparent liquid oozing out if you cut your finger; if you watch the cut carefully you may see it, and I contend that there is in every tooth, in the dentine and enamel, this bioplasm. Tomes claims to have seen nerve fibers in it, McGill has denied it. I stated that we could not prove the existence. There is the bioplasm that affords a large amount of moisture. When the tooth has been attacked and the cavity has extended some distance, there is an effort of the bioplasm to resist, shown by ossification shutting out the organisms, but very often they are too strong and get the start, and the tooth has to succumb; but if the bioplasm of the tooth or the mesh-work should be sufficiently organized to fight the little enemy successfully, I do not think that decay would be very apt to occur. In the case of Dr. Rich, I would say, if the cavity was hermetically sealed, as Dr. Rich supposed, that it would be perfectly safe unless some abnormal conditions should occur. This question might require a great deal of fine argument.

Dr. WHITE: Concerning the very question of Dr. Rich, I would state that in a paper read before the State Society, a year ago, I took that ground. In the last three or four years, I probably filled all large cavities in this manner. I first filled in oxyphosphates or oxychlorides, and at the expiration of a week or ten days, sometimes as long as two years, I capped the soft material with something harder, gold or amalgam. I think I can say that it is a most successful process. I have always applied the rubber dam before removing the soft material, and filling with the hard material. I have never found gutta-percha to fill hermetically a cavity; I believe that it is so unreliable in this direction that I never employed it except temporarily.

Dr. RICH: I have put this question for the very reason that I have been practicing this method for the last six years and have succeeded wherever I expected.

Dr. WHITE: I think that Dr. Clark has a tooth in his mouth that was filled that way ten years ago; it may be twelve years ago.

Dr. F. Y. CLARK: The tooth is there now.

Dr. LOVEJOY: I would like to ask Dr. Rich with what material he usually fills the cavities in the cases mentioned.

Dr. RICH: I would say that I more particularly fill the cavities in this way where there are chances of permanent fillings producing bad results, and where there is nearness to the pulp or exposure; I do not mean to say that I do it in all cases; you could not do that.

The next subject is the paper of Dr. C. T. Stockwell, of Springfield. (See next number.)

[To be continued.]

SELECTIONS.

ARTHUR S. UNDERWOOD'S REPLY TO DR. FRANK ABBOT.

To the Editor of the "Journal of the British Dental Association."

DEAR SIR: In your last issue you quote some utterances of Dr. Frank Abbot upon dental caries, which more or less demand an explanation from those who differ from him with regard to the pathology of the disease. The criticisms of Dr. Abbot upon the germ theory will possibly be more valuable when the critic has had time and opportunity to study the nature of micro-organisms and find out what they really are. At present, as he says, he fails to find them in carious cavities. I can only conclude that he does not use the word germ in the same sense as Pasteur and Lister, and under these circumstances he can possess only a very confused notion of the septic theory of caries. The only statement in the first page of your quotation which might not have been culled from any of the current handbooks for the last ten years, is that micrococci prosper in alkaline, but never in acid fluids, which statement is clearly incorrect. Leaving this page, the next original statement is that it is easy to demonstrate the fact that the irritation of the animal matter in the enamel (presumably the tissue observed by Heitzmann and Bödecker between the prisms) passes beyond the "point at which absolute destruction of the tissue has taken place." Now seeing that the very existence of this tissue is so difficult of demonstration that many

careful observers are not quite convinced of its existence, and that it is absolutely avascular, it would require rather delicate microscopy to decide whether or not this minute thread was in a state of irritation; I cannot but suppose that words are here used to conceal their sense, or rather their nonsense. Whatever the "glue-giving basis substance" may be, it is described as "melting down," "bringing to view the medullary or embryonal elements of the enamel" (*sic*).

Dr. Abbot further assures us that enlarged canaliculi may be the scene of a healthy change, that the acids are removed, the inflammation subsides and the lime-salts are redeposited, leaving the structure to all appearances as healthy as before. How he arrived at this conclusion I cannot imagine, seeing that it would obviously be impossible to tell that the restored canal was ever diseased, unless a diseased canal could be watched under the microscope and seen to become restored. It would appear, therefore, that this observation rests upon Dr. Abbot's imagination alone, and yet he makes it the ground for assuming that it is unreasonable to pretend that the enlarged canaliculi are filled with organisms, in the face of the fact repeatedly vouched for by many observers in England and on the Continent, including Professor Koch, Dr. Miller (Berlin), Mr. Tomes, Mr. Mills, myself, and others, that such organisms are invariably found in such canals. Certainly if Dr. Abbot feels bound to discuss these matters, in order not to disappoint his friends and make strangers smile, he should either study the matter or avoid "original" statements, and content himself with the safer, if less glorious, process of abstracting or collating.

Dr. Abbott ends his paper by proposing four questions:

1. "Why is it that the teeth of all persons do not decay the same?" This has no reference to the germ theory because, as we took pains to point out when first broaching our theory, the initial stages of decay depend upon congenital or acquired weakness of the enamel, and facilities for the lodgment of the decay-producing agencies.

2. "Why are lower front teeth less liable to decay, although the greatest amount of organism may be found upon them?" This question arises apparently from a confusion in the mind of the questioner between leptothrix and micrococci. The latter are, so far as can be ascertained, equally distributed all over the mouth, except that they remain in greatest abundance between adjacent teeth, or in spaces where food can lodge.

3. "Why is it that teeth, with the greatest amount of lime-salts

and the smallest amount of organic matter (upon which organisms subsist), do not decay sooner and more rapidly than the reverse?" Granting, for the moment, that this is so, I should say, because the organisms, finding more pabulum in the more organic teeth, destroy them more readily, since they have more power of proliferation in such tissues—but unless supported by evidence the statement is a pure assumption.

4. "Why is it that a pulp canal which has held a dead and putrefying pulp for many years, upon being opened, is found as solid and free from decay as it was before the pulp died?" Firstly, *putrefying pulps* are generally destroyed and extracted, or cleaned and rendered pure, and teeth containing them are not left for years unopened (the result of which treatment would probaby be an alveolar abscess); but if Dr. Abbot simply means dead pulps sealed up, the organisms in such pulps do not live for more than a very brief space of time, as contact with the air and the fluids of the mouth, and the constant admission of fresh millions of organisms to the scene of action, are necessary to their active life.

In conclusion, I would again urge the absolute necessity of properly comprehending the nature and life, and mode of development of micro-organisms, before attempting to demolish by mere phrases hastily considered, observations which rest upon patient study, the proofs of which have been verified in many directions by independent observers.

With many apologies for trespassing at such length upon your valuable space,

I remain, Dear Sir, faithfully yours,

ARTHUR S. UNDERWOOD.

GELSEMIUM SEMPERVIRENS IN FACIAL NEURALGIA.

Dr. Spencer Thompson, of Torquay, thus replies to a correspondent in the *Midland Medical Miscellany:* My usual dose, unless I have reason to know or believe the patient is very sensitive, is *M* xx., repeating in an hour if there is no relief, and if there is no giddiness or affection of vision, I may give a third dose in four or five hours; but it is rarely required in suitable cases, and I seldom give less than *M* xv. I have found *M* v. relieve in a very sensitive subject. I mention 'suitable cases,' for my own experience has told me that gelsemium has little curative effect in any neuralgic affection but that involving the teeth and alveoli of upper and lower jaw. In such it often acts like a charm."—*The Dental Record*, London.

Books and Pamphlets.

"With compliments of the Odontographic Journal"—for which we say thank you—we received a little pamphlet entitled the "Physiology of Protoplasmic Motion" by Th. W. Engelman, of the University of Utrecht, translated by Charles S. Dolley, M. D., published at Rochester by Davis & Leyden.

The pamphlet is a careful collection of all the data and experiments relating to the motion of small protoplasmic bodies like amœbæ myxomycetes, actinospherium, æthalium septicum, &c. The writer has made comparatively few experiments himself, but the great number of foot notes show that he is a student. Mr. Schultze's experiments about the "heat tetanus" of miliola are quoted—that is, the temperature at which the protoplasmic threads become rigid in the position which they last occupied. No lowest temperature has yet been observed at which the protoplasmic bodies are killed. It also has been found that it does not matter much whether the thawing up is rapid or slow. Kühne observed the fact that tradescantia shows no trace whatever of the protoplasmic net-work after being quickly dried up; but, on being moistened, after a few seconds it becomes re-established.

Another interesting feature is mentioned, namely: that there exists a certain amount of water which is most favorable for the life of the protoplasm; protoplasm dies after a long continued treatment with distilled water, also by excessive drying. A "dry tetaunus" may be obtained, but protoplasms which have been completely dried in the air at ordinary temperatures may be revived after many years by the addition of moisture. Most forms of protoplasms accommodate themselves to a gradual change of concentration of a liquid, but most of them are destroyed by a rapid influence. The presence of oxygen is very essential to protoplasm. The motions cannot continue long without it; high pressure of oxygen diminishes the motion, diminished pressure increases it. Hydrogen does not kill protoplasms like a poison, it simply retards and finally arrests the motion. The writer quotes many experiments as to the effect of electrical currents, heat, and other irritants, on protoplasm. From all those experiments one may conclude that at first the protoplasmic motion is greatly affected by a change of circumstances, but very soon the former movements are resumed in protoplasms under circumstances which, if brought about suddenly, would have killed it without fail. This little pamphlet is well worth reading.

"Records of the Missouri State Dental Association, from its organization, 1865, to 1882."

Of interest not only to the Mo. State Asso., but valuable to the profession in general. The volume contains many excellent papers by prominent men in the profession.

MICROSCOPY. *The Essentials of Pathology.* By D. TOD. GILLIAM, M. D., Professor of Physiology, Starling Medical College. Philadelphia: P. Blakiston, Son & Co.

We remember hearing, some time since, one of our most eminent men of science—a *savant* in every sense—make the remark, "Regarding subjects with which I am unfamiliar, I find I always learn the most from elementary works," the comment being in reply to the criticism of incompleteness advanced regarding a text-book recommended to a tyro in paleonthology. Of no study of the medical student of to-day is a clear conception of fundamental principles more necessary than of pathology; yet how many are the first-course men, who turn the last page of Wagner or Rindfleisch, without having thoroughly comprehended a tithe of the broad and important generalizations, without a clear conception of which elaborate detail and minutiæ are meaningless. With this fact fully appreciated by the author the little volume before us was conceived; "not intended to supplant more pretentious works by allaying, but rather to lead up to them by kindling, a thirst for pathological investigation."

The wisdom of such books being admitted, upon two factors depends their true usefulness—accuracy and happy arrangement. While from its nature the contents is necessarily concisely stated, thereby, at times, leading to expressions rather dogmatical concerning points still admitting discussion, the pages before us will be found to present an excellent epitome of the generally accepted pathological doctrines, with a keen appreciation of the broader and more comprehensive and logical views of to-day.

The arrangement of the matter is well adapted to present the subject in a clear and attractive manner. The first third of the book discusses the more important divisions of general pathology; the following part treats of inflammation, inflammatory growths, and neoplasms; while the last hundred pages are devoted to special pathology, including that of the blood and simple tissues, and several of the more important organs.

While this little volume will find a warm welcome from many for the real aid offered to advanced study, it, in common with all of its scope and kind, presents the temptation to perversion of use by those —and, unfortunately, there are always such—to whom a superficial knowledge recommends itself by the minimum of study required, and to whom manuals and quiz-compends are certain to be the first—and too frequently the only—source of information.

We recommend every first-course student to make himself thoroughly familiar with the contents of Dr. Gilliam's book, being confident that his later experiences with elaborate and comprehensive works will not fail to be far more interesting and truly profitable than if they be attacked without preliminary reading of the kind here offered.—*Western Medical Reporter.*

"American Journalist," Vol. I., No. 1; published monthly at St. Louis, Mo., by the American Journalist Publishing and Printing Co., 505 Chestnut St. R. P. Yorkston, editor. Subscription price, $2.00. Single copies, 25 cents.

The Continental Magazine, published monthly by A. C. Meyer & Co., Baltimore, Md. P. O. Box No. 171.

The Western Medical Reporter, Chicago, Ill. "A Monthly Journal of Practical Medicine and Surgery." J. E. Harper, A. M., M. D., editor and manager. One of our best exchanges.

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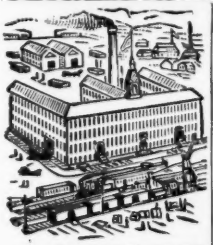

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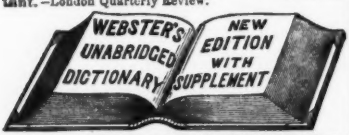

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